Nature of Matter

Introduction to Matter

The world around us is full of matter — the air we breathe, the water we drink, the food we eat, and even the gadgets we use. Matter is made up of tiny particles, and depending on how these particles are arranged, it can exist as a pure substance or a mixture. Mixtures are combinations where substances retain their properties, while compounds are new substances formed by chemical bonding of elements. Elements are the simplest form of matter, forming the building blocks for everything else. From ancient alloys like Mishraloha to modern stainless steel, and from the gases in the air to the minerals deep in the Earth, matter exists in different forms all around us. Studying the nature of matter helps us understand how the world works, how materials are made, and how science connects to our daily life.

What Are Mixtures?

A mixture is formed when two or more substances are combined in such a way that each substance keeps its original properties. Examples include poha made by mixing rice flakes, peanuts, onions, and spices; sprout salad containing sprouts, tomato, onion, and lemon; and sugar dissolved in water, lemonade, or soups.

Components of a Mixture

The substances that make up a mixture are called components. For example, in sprout salad, the components are green gram, chickpeas, onion, and tomato. Components do not react chemically with each other and can often be separated.

Types of Mixtures

Mixtures are of two types:

- **Non-uniform mixtures (heterogeneous mixtures):** Components are not evenly mixed and can be seen separately with the naked eye or under a magnifying glass. Examples include sprout salad, poha, and sand mixed with salt.
- **Uniform mixtures (homogeneous mixtures):** Components are evenly mixed and cannot be distinguished separately, even under a microscope. Examples include sugar dissolved in water, salt dissolved in water, and lemonade.

Alloys - Special Mixtures

An alloy is a uniform mixture of two or more elements, where at least one is a metal. Alloys are made to improve the strength, hardness, resistance to rust, and durability of metals. They are made by melting metals, mixing them in fixed proportions, and cooling. Examples include stainless steel (iron, nickel, chromium), brass (copper, zinc), bronze (copper, tin), and solder (tin, lead).

Our Scientific Heritage — Mishraloha

The word Mishraloha comes from Sanskrit: Mishra means mixed and Loha means metal. Mishraloha refers to a mixture of two or more metals, known today as an alloy. Ancient Indians knew that mixing metals could produce new materials with better properties than the original metals. These mixtures were stronger, more durable, and sometimes had medicinal benefits. For example, Kamsya is a mixture of copper and tin used to improve digestion and boost immunity, showing early knowledge of alloys in medicine and utensils.

Is Air a Mixture?

Air is a uniform mixture (homogeneous mixture) of gases including nitrogen (78%), oxygen (21%), argon, carbon dioxide, water vapour, and other gases in small amounts. Oxygen is needed for breathing and combustion, nitrogen maintains balance, water vapour forms dew or fog on cooling, and carbon dioxide is exhaled by humans and used by plants for photosynthesis. Air is a mixture because these gases are not chemically combined and each retains its own properties. The composition of air can vary slightly from place to place.

What Are Pure Substances?

A pure substance is made of only one kind of particle and cannot be separated into simpler substances by physical methods like filtering, sieving, or evaporation. Every part of a pure substance has the same composition and properties. Examples include elements like iron, copper, oxygen, and gold, and compounds like water (H□8O), carbon dioxide (CO□2), and salt (NaCl) which have fixed proportions of elements.

Types of Pure Substances

Elements

Elements are pure substances made up of only one kind of atom. They cannot be broken down into simpler substances by chemical methods. Examples include hydrogen, oxygen, gold, silver, sulphur, and carbon. Most atoms combine to form molecules, such as hydrogen molecules (H□2) and oxygen molecules (O□2). Elements can be classified into metals and non-metals. Metals like gold, silver, magnesium, iron, and aluminium are shiny, conduct electricity, and are malleable. Non-metals like carbon, sulphur, hydrogen, and oxygen are dull, brittle, and poor conductors. Some elements like silicon and boron have properties of both and are called metalloids.

Compounds

Compounds are pure substances made up of two or more elements chemically combined in a fixed ratio. For example, water (H□8O) consists of two hydrogen atoms and one oxygen atom in a fixed ratio of 2:1. Compounds cannot be separated by physical methods. Their properties are different from their constituent elements. For example, sodium (a reactive metal) and chlorine (a toxic gas) combine to form sodium chloride (common salt), which is edible. Elements in a compound cannot be separated by simple physical methods.

Minerals

Minerals are naturally occurring substances found in the Earth's crust. They are inorganic and usually solid. Minerals can be elements like gold and silver or compounds like quartz (silicon dioxide) and limestone (calcium carbonate). Minerals are the building blocks of rocks and ores.

Why Are Minerals Important?

Minerals show how elements, compounds, and mixtures exist in nature. They serve as the basis for metals, nonmetals, and a variety of other everyday materials. Examples include elements like gold and silver, compounds like haematite and bauxite, and mixtures like granite and ores.

Adulteration

Adulteration is the illegal process of adding cheaper or poor-quality substances to a product to increase quantity or reduce manufacturing cost. This deteriorates the quality of the product and can make it hazardous to health.

Key Differences Between Elements, Mixtures, and Compounds

Elements are made of only one type of atom and cannot be broken down into simpler substances. Mixtures contain two or more substances that keep their own properties and can be separated by physical methods. Compounds are made when two or more elements chemically combine, creating new properties different from the original elements. Examples include hydrogen and oxygen as elements; iron mixed with sulfur as a mixture; and water, sugar, and salt as compounds.

Solved Examples

Example 1: Identify whether the following are elements, compounds, or mixtures: (a) Air, (b) Water, (c) Gold, (d) Salt and sand mixed together.

Solution:

(a) Air is a mixture of gases (nitrogen, oxygen, etc.) so it is a mixture.

(b) Water (H□8O) is made of hydrogen and oxygen chemically combined in a fixed ratio, so it is a compound.

(c) Gold is made of only one type of atom, so it is an element.

(d) Salt and sand mixed together is a physical combination where both retain their properties, so it is a mixture.

Example 2: Explain why alloys are considered mixtures and not compounds.

Solution:

Alloys are mixtures because they are made by physically mixing two or more metals without chemical bonding. The components retain their individual properties and can be separated by physical methods. For example, stainless steel is a mixture of iron, nickel, and chromium. Since the metals are not chemically combined in fixed ratios, alloys are mixtures, not compounds.

Practice Set

Conceptual Questions

- **Level 1:** What is the difference between a mixture and a compound?
- **Level 2:** Why can the components of a mixture be separated by physical methods but not those of a compound?

Application-based Question

- **Level 3:** A sample contains two substances: one is a metal and the other is a non-metal chemically combined in a fixed ratio. Identify the type of substance and explain how it differs from an alloy.

Answer Key

Conceptual Questions

- **Level 1:** A mixture contains two or more substances physically combined where each retains its properties, while a compound is a substance formed when two or more elements chemically combine in fixed ratios forming new properties.
- **Level 2:** Components of a mixture retain their individual properties and are not chemically bonded, so they can be separated by physical methods. In a compound, elements are chemically bonded, forming new substances that cannot be separated by physical methods.

Application-based Question

- **Level 3:** The substance is a compound because it consists of a metal and a non-metal chemically combined in a fixed ratio. It differs from an alloy, which is a mixture of metals physically combined without chemical bonding.

Quick Reference Table

Key Terms and Definitions:

- **Matter:** Anything that has mass and occupies space.
- **Element:** Pure substance made of only one kind of atom.

- **Compound:** Pure substance made of two or more elements chemically combined in fixed ratios.
- **Mixture:** Physical combination of two or more substances where each retains its properties.
- **Alloy:** Uniform mixture of two or more metals.
- **Mineral:** Naturally occurring inorganic solid found in the Earth's crust.

Important Facts:

- Elements cannot be broken down by physical or chemical methods.
- Compounds have properties different from their constituent elements.
- Mixtures can be separated by physical methods.
- Air is a homogeneous mixture of gases.
- Alloys improve the properties of metals.

Common Mistakes and Misconceptions

- Confusing mixtures with compounds: Mixtures retain individual properties, compounds do not.
- Believing alloys are compounds: Alloys are mixtures of metals physically combined.
- Thinking air is a pure substance: Air is a mixture of gases.
- Assuming elements can be broken down: Elements are the simplest substances and cannot be broken down further.
- Mixing up homogeneous and heterogeneous mixtures: Homogeneous mixtures have uniform composition; heterogeneous mixtures do not.

Glossary

- **Atom:** The smallest unit of an element that retains its chemical properties.
- **Compound:** Substance formed when two or more elements chemically combine in fixed ratios.
- **Element:** Pure substance made of only one kind of atom.
- **Mixture:** Combination of two or more substances where each retains its properties.
- **Alloy:** Mixture of metals to improve strength and durability.

- **Mineral:** Naturally occurring inorganic solid found in the Earth's crust.